The Evolution of Tools and Implements.

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Man's happiness today is dependent upon the comforts with which he is surrounded. His home, his clothes, his city, and the great complexity of present day society are the things that make life desirable. The society of which he is a part is dependent for its existence upon a great multiplicity of mechanical devices. Thousands of men go to the steel mills each morning to care for the great furnaces where millions of tons of ore are converted into iron. Thousands of men go to the factories to make machinery and tools from the iron. Again, men use the tools to make machines—great mechanical devices—huge lathes capable of turning an engine wheel; dry docks to float the longest ship; valves through which an automobile can pass—it is upon these things we depend today. They did not come suddenly, but through long, continual inventive effort to use the materials at hand to the greatest advantage.

Before the invention of metals, man's supply of materials with which to work was the flint quarry, the gravel bank, and the chert ledge. His weapons and tools were made of stone; at first in the pieces just as they were picked up; later they were roughly chipped, and in the time just preceding the invention of bronze they were elaborately chipped, polished and often carved.

When man discovered that copper and copper and tin alloys would lend themselves to shaping quickly by pounding, and that the weapons so made could be ground to an edge much sharper than that obtainable in stone, he did not hesitate to discard the quarry for the mine. His stone implements were reproduced in bronze and improved as the toughness and malleability of the metal suggested. His daggers were longer, his axe shorter and less unwieldly, and his arrows had sharper points.

The supplies of bronze were limited, and hence its use was not greatly extended. It was only with the invention of iron smelting processes that man entered into the era of invention and manufacture whose comforts today we enjoy. With such supplies of metal at hand there was no limit to the advancement of mechanical invention. Steel followed as a logical re-

sult, and with the advent of scientific thought and its application to the industries, the mechanical progress in the last hundred years has been enormous.

Let us suppose that a colony of present day people, dependent upon a vast multiplicity of mechanical devices for their well-being, be deprived of all of these things which they look upon as necessary to life and be left upon some island well supplied with the flints, the ores of copper and tin and of iron. Supposing still that, in the course of the first six or seven generations, the metals remained undiscovered and the people had accustomed themselves to an existence upon such plants as could be found and game brought down with stones. The customs of their modern forefathers would soon be forgotten and they would revert to the savagery necessitated by their environment. Then would doubtless follow a repetition of the series of discoveries and inventions which marked man's advance to his present day status. The improvement of stone weapons, the discovery and use of bronze, the use of iron, and then of steel, would come even as it came before. It is true that such a colony would have the mental advantage of hundreds of generations of intensive thinking and inventive people, and that mentally they would be of a type much higher than the primitive users of unworked stones. For this reason the progress would probably be more swift, but the order and method of invention would undoubtedly be the same.

The classification of M. Adrien de Mortillet of simple tools in five groups is given in Table II. His first group contains tools for cutting, edge tools probably the first type to be developed . The older stone flakes referred to the Chellean, found in river terraces of the Paris basin, while known as a "hand-axe" by the English archaelogist, is better described by its French name—the Coup de Poing[1]—and was doubtless grasped in the hand and used as a knife.

From the roughly broken stone fragment held in the hand up to the elaborately chipped blade-like daggers of the American aborigines, made with a skill that no white man possesses, is simply a process of educational evolution—one process leading to the next.

Pointed knives of bone are found in the kitchen middens of

1. Geikie, Jas. Antiquity of Man in Europe. 1914. P. 43.

old Hochelaga[2] and knives of bamboo cane are used today by some Polynesian tribes.[3] Elsewhere bamboo is used in making handles for other implements.

Many peoples make elaborate handles for rude knife blades, and the preservation of the blade alone, a crudely chipped piece of flint, would give a very low impression of the mechanical art of the people, although the handle by which it was attached may have been elaborately worked.

The primitive shear was a flat flake of flint held in one hand and pressed against a flat stone held horizontally much as a saddler's draw-knife or a cigar maker's clip is used today. It may have been provided with a handle as the "ulu" or woman's knife of the Eskimo.[4]

The shear made of two movable blades passing over each other was found in ancient Egypt and in China, but was doubtless invented after the "ulu"type of shear had been in long use.

The axe is a development of the stone knife. It would be very difficult to wield a knife as long as many axe-heads without the use of a handle. It was doubtless a red letter day in the history of invention when some Acheulean genius found that by wrapping vines about a sharp flake of flint and twisting the ends into a handle he had produced the first axe.

Axes are in general use throughout Paleolithic times. The method of attachment to a handle varies greatly. In the Solutrean of South Africa[1] axes were found with slight longitudinal grooves chipped in such a manner as to be firmly held when inserted into a split stick. The head was often locked to the stick by means of green raw-hide which, contracting greatly in drying, binds the blade firmly to the handle. Many of the polished axe heads of Neolithic times are grooved to receive the split handle or lashings, as are many of the axes of the American Indians.

Matlocks, adzes and chisels must be considered as adaptations of axes. A stone axe, while of little use in chopping a log across the grain, is of great use mounted as an adze in splitting it or in hollowing it in the manufacture of a canoe. Likewise, the chisel is but an axe head set in a handle so that the blade is at the end of the handle, and a matlock a longer

2. Dawson, F. W., Fossil Men and Their Modern Representatives. 1870. P. 135.
3. Polynesian Researches, Vol. IV., P. 346.
4. Mason, "The Ulu, or Woman's Knife," Rep. U. S. Nat. Mus. 1890. Pp. 411-416.

adze. The stone blade in these types of cutting tools differed but little among primitive people, the same blade being used for all purposes.

The bronze celts of the Swiss Lake Dwellers are classical examples of the reproduction of stone tool types in bronze.

Osborn[5] fails to include the flint saw in his tables of implements, but Mason[6] mentions flint pieces with serrated edges found in many European as well as American caches. These flakes are carefully made and seem to be adaptable for no other purposes than hacking a piece of wood or bone in two.

The use of thin strips of soft wood and sand much as the modern quarryman cut his block of marble into slabs was probably known in Paleolithic times; undoubtedly in Neolithic.

In ancient Egypt a bronze saw was used, and very primitive cross-cut saws of the same metal are in use today in China.

The Aztecs and some modern Polynesian tribes make saws by inserting teeth and bits of stone in a wood handle.[7]

M. Adrien de Mortillet's second group comprises those instruments used for abrasion and for smoothing. He includes in it scrapers, gravers, rasps, files, sandpaper, polishers, burnishers, whetstones and grindstones.

The use of abrasives can not be considered a fundamental operation. Chipping and crushing doubtless came first and the abrasive process was used in finishing the tools roughly shaped by pounding or chipping.

Scrapers were used to prepare skins for use as clothing and coverings. The process of skinning an animal needs necessarily be crude when done with stone knives, and the use of a scraper to remove the mangled flesh from the skin is a normal development. They appear in the Chellean and are most conspicuously deveolped in the Mousterian and the Aurignacian of the Middle Paleolithic[8].

The instruments used in polishing stone are of small importance in the Paleolithic, but assume a prominent place among the implements of the Neolithic. Mason[9] tells of the many reports sent annually to the Smithsonian at Washington telling of the discovery of large blocks of sandstone whose

5. Johnson, J. P. The Prehistoric Period in South Africa. 1910. P. 51.
6. Osborn, H. F., Men of the Old Stone Age. Pp. 270, 271.
7. Mason. The Origin of Invention. 1901. P. 48.
8. Ibid. P. 48.
9. Loc. Cit. P. 52.

surface shows marks of abrasion indicating their use as grindstones.

The "kitchen middens" of the north of Europe contain whetstones made of the best material the locality affords. Today the whetstone is used by all savage peoples. Often hammers and axes show abrasive marks, telling of their use as grindstones.

Etchers and burnishers come into importance in the bronze age and many of the "Swiss Lake" implements are elaborately etched and doubtless were highly polished when new.

The third division of M. de Mortillet's includes implements use for fracturing, crushing and pounding.

Chipping instruments are in use by all savage people who work in such rock as flints and cherts. Almost all papers discussing flint blocks and arrows go into considerable detail in describing the method of using a pin of bone to do the final finishing of the implement. Today the implements are made of such materials as bone, antler, hardened wood and stone.

In using the chipper, the flint is held in the hand against a piece of leather or another stone, and pressure is exerted downward near the edge of the flint. In this way thin flakes of the material are chipped away and the implement fashioned.

Osborn[10] in his table does not include the chipper among his bone instruments, but there is no doubt that some of the instruments classified by him as chisels or as smoothers were used for this purpose.

The hammer is the universal tool. Dawson's[11] account of the evolution of the hammer is very good. He recognizes these types of hammers:

"Disc-hammers are in their rudest form merely flat pebbles, suitable to be held in the hand, for driving wedges or chisels, or for breaking stones, bones, or nuts. In their more finished forms they are carefully fashioned of quartzite or greenstone, with one side convex and the other flat, or even slightly hollowed, and the edge neatly and regularly trimmed. Stones of this kind are found all over America on old Indian sites, and are almost equally common in Europe; and there can be little doubt from the habits of the modern Indians as to their ordin-

10. Loc. Cit.
11 Dawson, F. W. Fossil Men and Their Modern Representation. London, 1880. Pp. 112-115.

ary uses. They were probably hammers, pounders and polishers. Held with the convex side in the palm of the hand, they could be used to drive wooden stakes or to split wood with stone chisels, or to crack nuts or to bruise grain and fruits, or to grind paint on a flat stone. With sand or earth they made efficient polishers for dressing skins, and held edgewise they served to trim flint weapons or to crack marrowbones. One of these hammers must therefore have been an indispensable utensil in every household, and a well-made one of durable stone may have been an heirloom handed down for generations.

"The second kind of hammer is of elongated form, round or oval in cross-section, and suited to be held in the hand, though, perhaps, in some cases lashed to a wooden handle. It much resembles the ordinary stone axe or celt, but differs in having a blunt end, indented with blows, instead of an edge. This almond shaped hammer was employed to chip stones, to drive wedges, and to break nuts and bones. One example from Hochelaga has a rough depression on one side, which may have been produced by hammering wedges with the side instead of the end, or may have been intended to give a better hold to the end of the handle. Hammers precisely of this kind are found in the caves of Perigord and in Sweden. The savages of all countries seem to have discovered that dioritic rocks, from the toughness of the crystals of hornblende which they contain, are specially suited for the formation of these hammers, so that wherever greenstone can be found it is employed.

"The third and most artificial kind of stone hammer is that with a groove around it, by means of which it could be attached to a handle or slung upon a tough withe. Such a hammer is sometimes merely an oval pebble with a groove worked around it, but some examples, especially those of the old mound builders, are elaborately grooved and carefully shaped; and there are some with two grooves, the working of which must have cost much labor. Some specimens are so small as to weigh only a few ounces, and one from the ancient copper mines of Lake Superior, now in the museum of the Geological Survey of Canada, is 11½ inches long, and weighs more than 25 pounds. The larger end of it has been much bruised and

broken, and it was evidently a miner's sledge-hammer. Grooved stones of this kind occur on prehistoric sites in Europe, though they have sometimes been regarded as plummets or sling-stones. In America similarly grooved pebbles are often found in circumstances which lead to the belief that they have been sinkers for nets. These are, however, usually of stone too soft to have been used for hammers, and have no marks of use on the ends. The ordinary sinker for lines and nets is, however, on both sides of the Atlantic a pear-shaped or drop-shaped stone, with a grove for the line at the sharp end."

Grinding apparatus is in universal use. The mortar appeared in Azilian times but flat stones were used for crushing grain long before. The lava mortar of Mexican peons is in use extensively in Mexico, and is but little better than those of much more primitive cultures.

In M. de Mortillet's fourth class are included instruments designed for use in perforating.

The borer is recognized from Pre-Chellean times, and remained a recognizable, though not conspicuous, element in the cultured throughout Palaeolithic times. It was used largely for boring out pieces of wood for blade sockets and in the dressing of the skins of the animals slain by the primitive man. Its use upon stone is uncertain in the Palaeolithic, but the use of rock drills in the Neolithic is well shown by the axe-heads of polished stone having a socket for the insertion of a handle found in the late Paleolithic.

The use of stone drills among the North American Indians is attested to by the presence of the calumet in any large collection of Indian implements.

The needle appeared in Magdalean times and was conspicuous among the implements of the Azilian and Tardenoisian. It was usually in the shape of a long thin piece of bone, without an eye, and used much as the shoemaker's awl is today. With it the old stone age people sewed the animal skins to make clothing.

The late Neolithic and the Bronze Age needles were more elaborate[12] and were in many cases provided with eyes. Other boring tools of the Bronze Age were gimlets, and punches, but the prototype of the modern augur is absent. The principle

12. Am. Rep. Peabody Mus., Cambridge. 1887. Pp. 581-586.

of the screw was unknown and may be considered a true product of modern invention, for in Archaelogical discussion Archimedes has not as yet been relegated to the "bone yard."

M. de Mortillet's last class included implements for grasping and joining. He divides this into two sub-groups, (a) including such articles as tongs, pincers, vices, clamps, and wedges, and (b) nails, lashings and glues.

Logically his second group should come first, for glues and lashings are known to savagery long before pincers and clamps.

From the most primitive culture, in fact wherever implements of stone are used, they are set into handles, and use is made of glue to hold them there. The Australian "black-boy" holds the stone point in the javelin, and modern Indians imbed a part of the blade of their flint daggers in pitch to provide a handle.

Nails are not new. Their forerunner—pins—are found in the upper Paleolithic made of bone. The Mormons used wooden pegs to hold together the timbers of their tabernacle at Salt Lake just as timbers are joined in China today. The buildings of the primitive peoples have long ago been destroyed, but it is not logically wrong to suppose they used such methods of joining as do peoples of comparable cultures who live today.

The vice and pincers are recent devices. When the old stone age man split a stick to insert the javelin point and then bound the split stick below the point with green rawhide he was using the principle of the vice. The old fable of the bear whose head became fastened in a split log when he dislodged the wedge which held it apart in his eagerness for the honey it contained, suggests to us the possible manner in which the vice was invented. Later day types in the late bronze age are included in collections of Roman tools.

In the discussion of these types of implements a parallelism has been attempted between the modern savages and those old types whose cultures are comparable with those of present day types. On the whole, this parallelism is satisfactory, and the use of many an old tool has been explained by the observance of present-day savage people.

TABLE I.

SUCCESSION OF HUMAN INDUSTRIES AND CULTURE.*

V. Later Iron Age.—Europe, 500 B. C.

IV. Earlier Iron Age.—(Hallstatt Culture.)—Europe, 1000-500 B. C.; Orient, 1800-1000 B. C.

III. Bronze Age.—Europe, About 2000-1000 B. C.; Orient, About 4000-1800 B. C.

II. New Stone Age, Neolithic.

3. Late Neolithic and Copper Age. (Transition period).—Europe, 3000-2000 B. C.

2. Typical Neolithic Age (Swiss Lake Dwellings).—Europe 7000.

1. Early Neolithic stages (Campignian culture).—Europe.

I. Old Stone Age, Palaeolithic.

Upper Palaeolithic—Europe.

8. Azilian—Tardenoisian.

7. Magdalenian (Close of post-glacial time).
6. Solutrean (Beginning of post-glacial time).
5. Aurignacian (Beginning of post-glacial time).

} Reindeer, Shelter, Drift, and Cave Period—12,000 16,000 B. C.

Lower Paleolithic.

4. Mousterian (Fawlk—Glacial time).—40,000 B. C.
3. Acheulean (Transition to Shelter).
2. Chellean.
1. Pre-Chellean

} River, Drift and Terrace Period 100,000 B. C.

Eolithic.

* Osborn, H. F., Men of the Old Stone Age. 1916. Scribners. P. 18.

TABLE 2.

M. ADRIEN DE MORTILLET'S CLASSIFICATION OF SIMPLE TOOLS.*

I. For Cutting. Edge Tools.
Working—
1. By Pressure
   a. Knives.
   b. Double-edge tools, shears.
   c. Planes.
2. By Shock
   a. Axes.
   b. Adzes.
   c. Chisels, gouges.
3. By Friction
   a. Saws.

II. For Abrasion and Smoothing.
Working—
1. By Pressure and Friction.
   a. Scrapers, gravers, rasps, files, sandpapers, polishers, smoothers, burnishers, whetstones, grindstones.
2. By Shock.
   a. Bush-hammers.

In wood-working fire is an efficient element in abrasion.

III. For Fracturing, Crushing, Pounding.
Working—
1. By Pressure.
   a. Chipping and flaking implements.
2. By Shock.
   a. Hammers, pestles.
3. By Friction
   a. Grinding apparatus, mills.

IV. For Perforating.
Working—
1. By Pressure and Friction.
   a. Needles, prickers, awls, drills of all kinds.
2. By Shock.
   a. Punches, pricks.

V. For Grasping and Joining.
1. Tongs, pincers, vises, clamps, wedges.
2. Nails, lashings, glues.

* Mason, Otis T. The Origin of Invention. Scribners, 1901. Page 34. Cit. "Rev, Mensuelle de l'Ecole d'Anthrop, Paris."

TABLE 3.

THE STONE IMPLEMENTS CHARACTERISTIC OF LOWER AND UPPER PALAEOLITHIC TIMES.*

The Typical Stone Implements.	Pre-Chellean	Chellean	Acheulean	Mousterain	Aurignacian	Solutrean	Magddelenian	Azilian	Magddelenian
A. War and Chase.									
1. Arrow Point, etc.							§	§	†
2. Point			§	†	†	§	§	§	
3. Lance or Knife					§	†	§		
4. Lance-Head					§	†	‡		
5. Lance-Head					‡	†	‡		
6. Hand-Axe, Poniard, etc.		†	†	§					
7. Throwing Stone	‡	‡	§	§	‡	‡	§		
8. Knife	§	§	§	§	§	§			
B. Industrial and Domestic.									
9. Lamp							§		
10. Polisher						§	§		
11. Mortar							§		
12. Chopper		‡	§	§					
13. Hand-Axe, etc.		†	†	§					
14. Planing Tool	§	§	§	§	§	§			
15. Scraper	§	§	§	†	†	§	§	§	
16. Drill, Borer	§	§	§	§	§	§			
17. Knife	§	§	§	§	§	§			
18. Anvil Stone					§	‡	§		
19. Hammer-Stone	§	§	‡	‡	§	§	§	§	
C. Art, Sculpture, Engraving.									
20. Drill, Graver, and Etcher					§	§	§	†	§
21. Chisel					§	§	§		
22. Etching Tool					†	†	§	§	
23. Graver (Also mortar, hammer-stone, and polisher)					†	§	§	‡	

* Osborn, H. F., Men of the Old Stone Age. Scribners, 1916. P. 270.

§ Twice mentioned (in different classifications).

† Denotes an unusual or culminating development.

TABLE 4.

THE BONE IMPLEMENTS APPEARING AT THE CLOSE OF THE LOWER PALAEOLITHIC AND HIGHLY CHARACTERISTIC OF THE UPPER PALAEOLITHIC.*

The Typical Bone Implements.	Aurignacian	Solutrean	Tardenoisian	Azilian	Tardenoisian
A. War, Chase, Fishing.					
1. Blades		§	‡	§	
2. Dagger			§	§	
3. Fish-Hook		‡	‡	‡	
4. Spear Thrower				§	
5. Harpoon			§	†	§
6. Javelin Point		§	§	§	
7. Spear Point		§	§	§	§
B. Industrial and Domestic.					
8. Spatula			§	§	
9. Shuttle				§	
10. Pin.				§	
11. Needle	§	§	†	†	
12. Blades		§		†	
13. Anvil	§				
14. Smoother		§	§	§	§
15. Wedge		§		§	
16. Chisel		§		§	§
17. Awl	§	§	§	§	§
C. Ceremonial, Social.					
18. Ceremonial Staff		§	†	†	
19. Wand				§	

* Osborn, H. F., Men of the Old Stone Age. Scribners, 1916. P. 271.

§ Twice mentioned (In different classifications).

† Denotes an unusual or culminating development.